

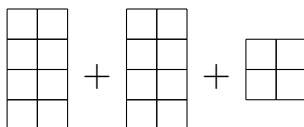
You are free to use the computer to confirm calculations, so long as you try to gain confidence in your ability to do calculations by hand. Typically, it's wise to use the computer but *distrust it*. Take the time to make sure the answers it gives make sense to you! Show all work.

1. Convert the following to canonical form:

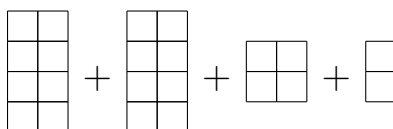
- (a) $5\clubsuit_2$.
- (b) $\clubsuit_2 + \clubsuit_2$
- (c) $\clubsuit_2 + \clubsuit_2 + \clubsuit_2$
- (d) $\clubsuit_2 + \clubsuit_3$
- (e) $\clubsuit_2 + \heartsuit_2$
- (f) $\clubsuit_2 + \uparrow$

2. For each of the following three domineering positions, evaluate the canonical form of the sum and determine whether you should play Left, Right, first, or second.

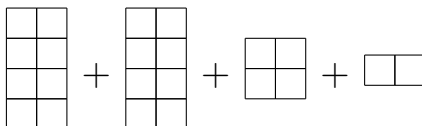
(a)



(b)



(c)



3. Fix a particular (partial) hackenbush position H , with one edge e unspecified. Assume that one (or both) endpoints are connected to ground. Four different positions can be obtained depending on whether edge e is blue, green, red or missing. Give the partial order on these four games, and prove that the partial order is independent of the position. As always, induction is preferred over arguments like, "and then right continues to..."